CENTRAL VALLEY
FLOOD MANAGEMENT
PLANNING PROGRAM

FloodSAFE
CALIFORNIA

Public Draft

2012 Central Valley Flood Protection Plan

Attachment 8I: Benefit Assessment

January 2012

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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1.0 Introduction

This section provides the purpose of this attachment, background information (including planning areas, goals, and approaches), and report organization.

1.1 Purpose of this Attachment

The 2012 Central Valley Flood Protection Plan (CVFPP) includes the formulation of four systemwide approaches, including the State Systemwide Investment Approach (SSIA). These approaches present different combinations of potential flood management improvements to address flood risk challenges. This attachment highlights potential ways of assessing economic benefits and describes a benefit assessment approach to be conducted for the CVFPP.

1.2 Background

As authorized by Senate Bill 5, also known as the Central Valley Flood Protection Act of 2008, the California Department of Water Resources (DWR) has prepared a sustainable, integrated flood management plan called the CVFPP, for adoption by the Central Valley Flood Protection Board (Board). The 2012 CVFPP provides a systemwide approach to protecting lands currently protected from flooding by existing facilities of the State Plan of Flood Control (SPFC), and will be updated every 5 years.

As part of development of the CVFPP, a series of technical analyses were conducted to evaluate hydrologic, hydraulic, geotechnical, economic, ecosystem, and related conditions within the flood management system and to support formulation of system improvements. These analyses were conducted in the Sacramento River Basin, San Joaquin River Basin, and Sacramento-San Joaquin Delta (Delta).

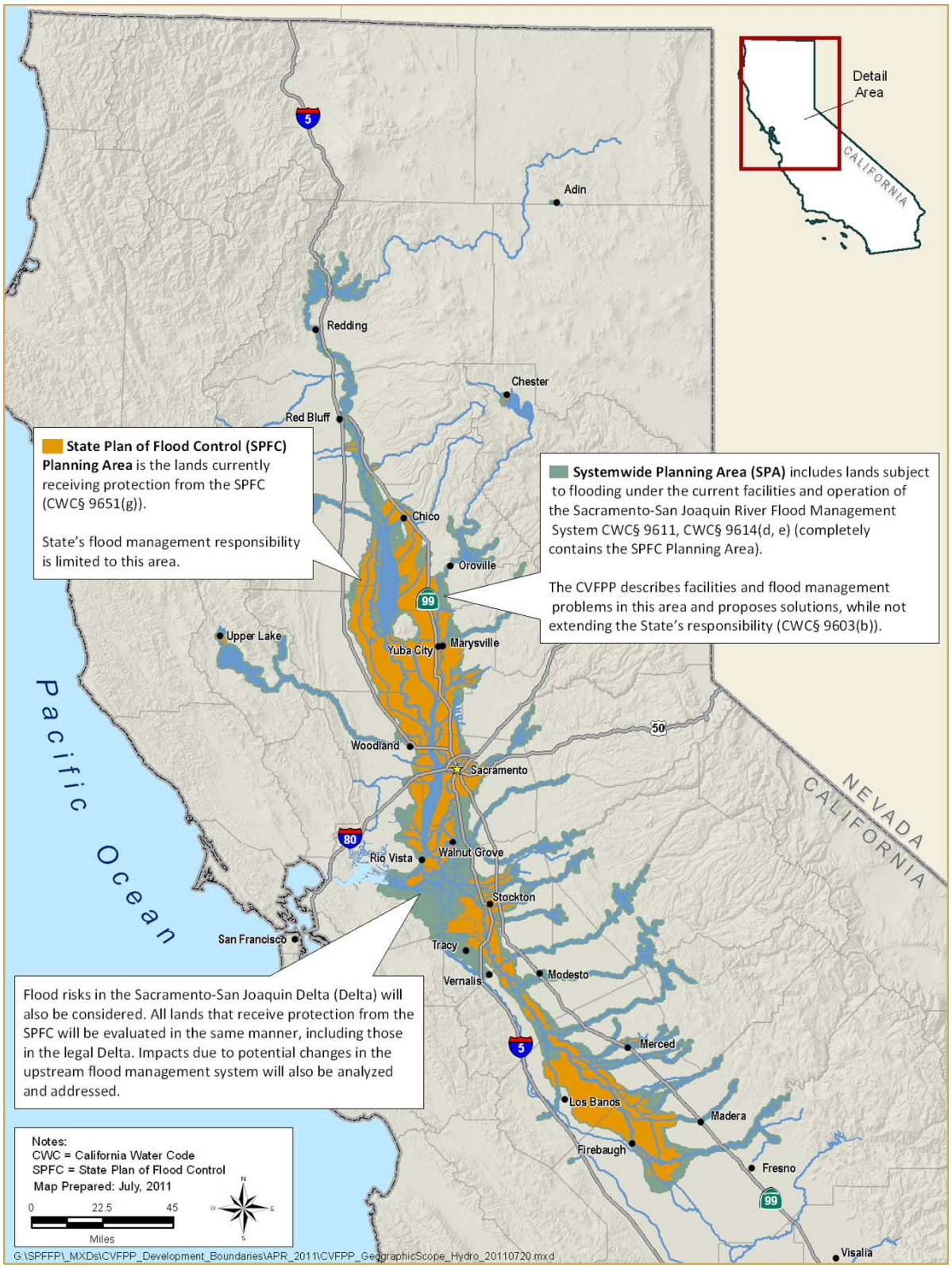

Figure 1-1. Central Valley Flood Protection Plan Planning Areas

1.1 CVFPP Planning Areas

For planning and analysis purposes, and consistent with legislative direction, two geographical planning areas were important for CVFPP development (Figure 1-1):

- **SPFC Planning Area –** This area is defined by the lands currently receiving flood protection from facilities of the SPFC (see *State Plan of Flood Control Descriptive Document* (DWR, 2010)). The State of California's (State) flood management responsibility is limited to this area.

- **Systemwide Planning Area –** This area includes the lands that are subject to flooding under the current facilities and operation of the Sacramento-San Joaquin River Flood Management System (California Water Code Section 9611). The SPFC Planning Area is completely contained within the Systemwide Planning Area which includes the Sacramento River Basin, San Joaquin River Basin, and Delta regions.

Planning and development for the CVFPP occurs differently in these planning areas. The CVFPP focused on SPFC facilities; therefore, evaluations and analyses were conducted at a greater level of detail within the SPFC Planning Area than in the Systemwide Planning Area.

1.2 2012 CVFPP Planning Goals

To help direct CVFPP development to meet legislative requirements and address identified flood-management-related problems and opportunities, a primary and four supporting goals were developed:

- **Primary Goal**: Improve Flood Risk Management

- **Supporting Goals**:

  - Improve Operations and Maintenance

  - Promote Ecosystem Functions

  - Improve Institutional Support

  - Promote Multi-Benefit Projects

1.3 2012 CVFPP Planning Approaches

Approaches to flood management were initially compared to explore potential improvements in the Central Valley. These approaches are not alternatives; rather, they bracket a range of potential actions and help explore trade-offs in costs, benefits, and other factors important in decision making. The preliminary approaches are as follows:

- **Achieve SPFC Design Flow Capacity** – Address capacity inadequacies and other adverse conditions associated with existing SPFC facilities, without making major changes to the footprint or operation of those facilities.

- **Protect High Risk Communities** – Focus on protecting life safety for populations at highest risk, including urban areas and small communities.

- **Enhance Flood System Capacity** – Seek various opportunities to achieve multiple benefits through enhancing flood system storage and conveyance capacity.

Comparing the preliminary approaches helped identify the advantages and disadvantages of different combinations of management actions, and demonstrated opportunities to address the CVFPP goals to different degrees.

Based on this evaluation, a **State Systemwide Investment Approach** (SSIA) was developed that encompasses aspects of each of the preliminary approaches to balance achievement of the goals from a systemwide perspective, and includes integrated conservation elements. Figure 1-2 illustrates this plan formulation process.

This attachment documents the benefit assessment conducted for the No Project condition and each of the approaches.

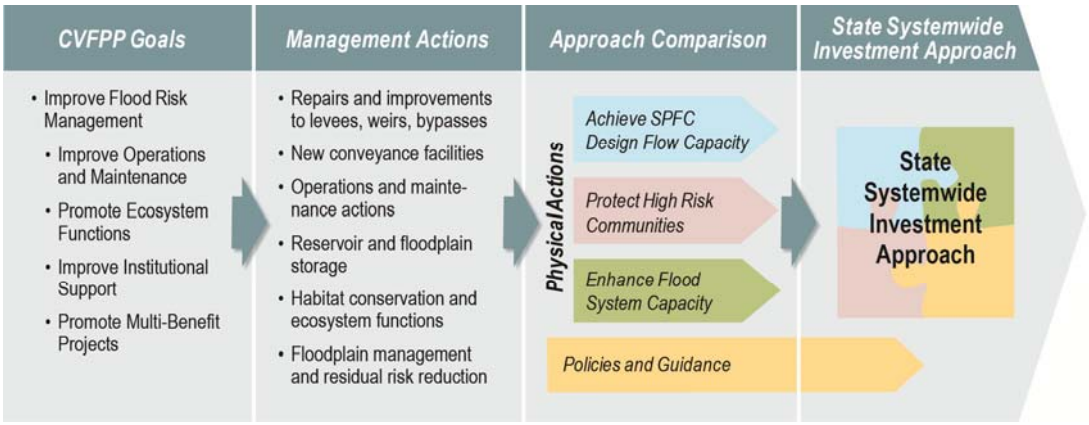

Figure 1-2. Formulation Process for State Systemwide Investment Approach

1.4 Report Organization

Organization of this document is as follows:

- Section 1 describes the purpose of the attachment, provides background information on the CVFPP, and describes CVFPP planning areas, the CVFPP planning process, and planning approaches.
- Section 2 provides an overview of key State and federal guidelines and considerations for benefit assessment.
- Section 3 describes the benefit assessment approach used in the 2012 CVFPP.
- Section 4 summarizes the benefits quantitatively assessed for the 2012 CVFPP.
- Section 5 describes the benefits qualitatively considered for the 2012 CVFPP.
- Section 6 provides a summary of findings of the benefit assessment.
- Section 7 contains references for the sources cited in this document.
- Section 8 lists abbreviations and acronyms used in this document.

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2.0 Guidelines and Considerations for Benefit Assessment

This section provides background information on State and federal guidelines for benefit assessment for flood improvements and related water management purposes. It also gives an overview of economic evaluation methods for different types of benefits.

Benefits are the increased values of goods and services produced by a project. Benefits play a critical role in determining the economic justification of a project and in allocating costs among different purposes. The CVFPP is expected to provide multipurpose benefits, including flood damage reduction, ecosystem restoration, and other water resources-related benefits, requiring different measurement methods, as described below.

2.1 Monetary Methods of Benefit Valuation

Where possible, benefits are expressed in monetary terms. The monetary value of a good or service to a person who is a buyer is equal to his or her "willingness to pay" for the outputs of the project. Because flood risk reduction projects can provide both private and public benefits, a number of market and nonmarket methods to estimate "willingness to pay" for the project outputs can be used, including the following:

- **Revealed willingness to pay,** in which values are determined from market prices such as prices paid for goods directly produced from the project, prices paid for related goods (e.g., higher prices paid for homes with views), or prices paid for travel to a recreation area. Some goods and services are used as inputs in production (i.e., improved water quality can lead to improved crop production), and their value may be measured by their contribution to the value obtained from the final goods, usually measured by changes in net income.

- **Imputed willingness to pay,** in which value can be estimated based on (1) reduction of costs, or (2) avoided (more costly) alternatives.

- **Expressed willingness to pay,** in which value is estimated through surveys (contingent valuation) that query people directly regarding what they are willing to pay based on a hypothetical scenario, or what they would be willing to accept in compensation if an amenity were taken away. Alternatively, people can be asked to make trade-offs

among different alternatives, from which their willingness to pay can be estimated (contingent choice).

- **Benefit transfers,** in which values developed by other studies for similar projects are transferred to the projects being evaluated.

- **Administratively established values,** in which representative values for specific goods and services are cooperatively assigned by water resources agencies.

Table 2-1 summarizes the benefit valuation methods that are typically used for different water management project purposes. The CVFPP is expected to provide many of these benefits.

Table 2-1. Water Management Benefit Valuation Methods

Benefit Valuation Method	Water Management Purpose							
	Water Supply	Water Quality	Hydropower	Flood Damage Reduction	Navigation	Recreation	Ecosystem Restoration	Fisheries
Revealed willingness to pay								
Market price	■		■					■
Price of related goods							■	
Travel cost						■	■	■
Imputed willingness to pay								
Reduction in costs	■	■	■	■	■	■	■	■
Alternative costs avoided	■	■	■	■	■	■	■	■
Expressed willingness to pay								
Contingent evaluation	■					■	■	■
Contingent choice	■					■	■	■
Benefit transfers	■	■	■	■	■	■	■	■
Administratively established values						■		

Source: Adapted from DWR, 2008

2.2 Nonmonetary Methods of Benefit Valuation

Nonmonetary methods do not place a monetized value on project benefits. Without a monetary measure of benefits, it is not possible to conduct a traditional benefit-cost analysis. However, short of benefit-cost analysis, economics can provide other methods of valuation to assist investment decisions. Two of these methods are cost effectiveness analysis and incremental-cost analysis:

- **Cost effectiveness analysis** is used to filter out plans that produce the same output level as other plans, but cost more.

- **Incremental cost analysis** shows changes in costs as levels of outputs increase.

The results of these analyses can permit decision makers to compare progressively alternative levels of project outputs and ask if the next level is "worth it." That is, is the additional output in the next attainable level worth its monetary cost? However, a major disadvantage of projects evaluated with cost effectiveness and incremental cost analysis is that conducting a "combined" analysis for multi-objective projects, which have monetized benefit values, is more difficult (USACE IWR, 1995).

2.3 Tools for Multi-Benefit Analysis

Numerous economic analysis computer software packages and other analytical tools can be used to assist in water resources economic justification and socioeconomic impact analyses. These are described in DWR's *Economic Analysis Guidebook* (DWR, 2008).

2.4 Consideration of Federal Principles and Guidelines

Water resources projects are often large and costly, and require cooperative efforts and resources from the local agencies that will directly benefit from the project, the State, and the federal government. In many cases, a large portion of the funds to complete water resources projects, and especially flood risk management projects, is obtained through federal funding programs. As a result, State projects are analyzed and formulated with consideration of federal guidelines as embodied in the federal Economic and Environmental Principles and Guidelines for Water and Related land Resources Implementation Studies (P&Gs) (WRC, 1983; DWR, 2008).

2.4.1 1983 Federal Principles and Guidelines

The 1983 P&Gs were established pursuant to the Water Resources Planning Act of 1965 (Public Law 89-80) to be followed by USACE, U.S. Department of the Interior, Bureau of Reclamation, Tennessee Valley Authority, and Natural Resources Conservation Service. The P&Gs set forth *principles* "intended to ensure proper and consistent planning by federal agencies in the formulation and evaluation of water and related land resources implementation studies" and *guidelines* that "establish standards and procedures for use by federal agencies in formulating and evaluating alternative plans for water and related land resources implementation studies." The P&Gs describe four planning accounts that provide a framework for project evaluation:

1. **The NED** account shows changes in the net value of the national output of goods and services expressed in monetary units, representing the direct benefits that result from the project. Documentation of the NED account is required for federal projects, whereas display of the other accounts is discretionary.

2. **The environmental quality (EQ)** account shows nonmonetary effects on ecological, cultural, and aesthetic resources, including the positive and adverse effects of ecosystem restoration plans.

3. **The regional economic development (RED)** account shows changes in the distribution of regional economic activity such as income and employment.

4. **The other social effects (OSE)** account shows plan effects on social aspects, such as impacts on communities, health and safety, displacement, energy conservation, and other effects.

The federal objective of these studies is to maximize NED through development of NED plan while protecting the nation's environment, pursuant to applicable laws and requirements. However, USACE has recognized that water management planning must fully evaluate all four accounts (USACE IWR, 1995).

2.4.2 Proposed Federal Principles, Requirements and Guidelines

Efforts are underway on the national level to update the P&Gs to become Principles, Requirements and Guidelines (PR&Gs). Proposed revisions include several changes that focus on the following:

- Achieving coequal goals
- Considering monetary and nonmonetary benefits
- Avoiding the unwise use of floodplains
- Increasing transparency and "good government" results

The proposed PR&Gs have potential implications for future CVFPP economic analyses. For example, although the current P&G include four accounts to evaluate projects, only the NED account is required. Thus, many analyses only focus on economic development benefits that can be included in a benefit-cost analysis. This was a common criticism of the current P&Gs; the proposed PR&Gs would make economic, environmental, and social goals "coequal." Because of difficulties in measuring how well a project meets noneconomic goals, the proposed PR&Gs recognize that monetary and nonmonetary benefits must be considered. The net effect of these changes should be to broaden project evaluation methods and metrics, which should, in turn, be consistent with evolving DWR policies on systemwide benefit assessment.

2.5 DWR Potential Systemwide Benefit Policy

In the California FloodSAFE (FloodSAFE) planning process, a plan consists of measures to improve integrated flood risk management. Alternative plans are formulated by combining different types, sizes, or locations of measures. The plans are evaluated, and a preferred plan is selected based on projected systemwide benefit and total cost.

Because a State standard definition of systemwide benefit had not been established, DWR has developed a potential policy that defines systemwide benefit and provides methods for describing and evaluating expected benefits from potential investments in flood risk management plans. The policy is based on the following:

- Historical perspectives
- The proposed federal PR&Gs
- DWR, Federal Emergency Management Agency, and USACE guidance

The 2012 CVFPP proposes a systemwide investment approach that will lead to systemwide feasibility studies and identify systemwide benefits. The goal is for the 2012 CVFPP planning process to be consistent with the proposed systemwide benefit policy, when it is adopted.

2.5.1 Flood Risk Management Benefit Categories

The DWR potential systemwide benefit policy lists benefit categories that could be considered in a systemwide benefit analysis. The policy also lists for each category how the benefit could be computed and whether the benefit could accrue from a State, federal, regional, or local perspective. The policy includes these types of flood risk management benefits:

- **Inundation-Reduction Benefits** – An inundation-reduction benefit is the value of reducing flood losses to existing economic activity present in the floodplain land in the absence of any further action or plan. There are four general types of inundation-reduction benefits:

    1. **Direct tangible** – Monetary damage caused by contact with floodwater.

    2. **Indirect tangible** – Monetary damage caused without contact with floodwater.

    3. **Direct intangible** – Nonmonetary damage caused by contact with floodwater.

    4. **Indirect intangible** – Nonmonetary damage caused without contact with floodwater.

- **Intensification Benefits** – An intensification benefit is the value of intensifying the existing use of land, such as shifting from lower value to higher value crops or to higher yield crops.

- **Location Benefits** – A location benefit is the value of making floodplain land available for a new economic use, such as shifting from agricultural to industrial use.

- **Secondary Economic Effects** – Most direct, or primary, monetary losses (or gains) will have secondary "ripple" effects (both positive and negative) in a regional, State, or even national economy. Secondary effects include:

    1. Indirect effects. Changes in output, income, and employment of a given industry resulting from the iterations of industries purchasing from the other industries caused by the direct effects.

    2. Induced effects. Changes in output, income, and employment caused by household expenditures generated by direct and indirect economic effects.

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3.0 2012 CVFPP Benefit Assessment Approach

This section describes the benefit assessment approach used in the 2012 CVFPP, including a summary of the benefit categories considered.

3.1 Benefit Categories Considered

The preliminary approaches and the SSIA were formulated to primarily improve flood risk management and to contribute to the other supporting goals, reflecting a wide range of benefits, including the following:

- **Improved public health and safety** – Flood management improvements can reduce the potential for injuries and loss of life, and release of hazardous materials during floods.

- **Reduced economic flood damages** – Flood management improvements can reduce damages to structures (residential, commercial, industrial, and government buildings), agricultural crop losses and livestock losses, damages to public infrastructure (transportation, energy, utilities, etc.), and business income losses.

- **Benefits to local and regional economies** – Flood management improvements can reduce the potential for loss of production and industry relocation, effects on employment, impacts on agricultural sustainability, and potential for disruption of public services. In addition, investment in flood improvements can result in positive regional economic effects.

- **Reduced long-term system management costs** – Flood management improvements can reduce long-term emergency response and recovery needs, and long-term operations and maintenance costs. Additional benefits can also be gained from implementing regional approaches to permitting and regulatory compliance to reduce long-term costs of project implementation and maintenance.

- **Increased flood system resiliency and climate change adaptability** – Flood management features such as storage and floodway expansion can enhance system adaptability to future changes in climate and hydrologic uncertainties, and to changes in population and land uses.

- **Ecosystem Restoration Benefits** – Restoration features integrated in flood management improvements can contribute to improved riparian habitat quantity, quality, and connectivity, and enhanced fish passage and habitat.

- **Water Management Benefits** – Certain flood management features can contribute to water supply and quality.

- **Open Space and Recreation Opportunities** – Certain flood management features can enhance the open space and opportunities for recreation and tourism.

Table 3-1 displays the relationships between these benefit categories and the CVFPP goals, 1983 federal P&G requirements, and proposed federal PR&G requirements.

Table 3-1. CVFPP Benefits Categories Related to CVFPP Goals, and Existing Federal P&Gs and Proposed PR&Gs

Considered Benefit Categories	2012 CVFPP Goals					1983 P&G Accounts				Proposed PR&G Coequal Goals		
	Improve Flood Risk Management	Improve Operations and Maintenance	Promote Ecosystems Functions	Improve Institutional Support	Promote Multi-Benefits	National Economic Development	Environmental Quality	Regional Economic Development	Other Social Effects	Economic	Environmental	Social
Improved public health and safety	■			■					■	■		
Reduced economic flood damages	■	■		■		■				■		
Benefits to local and regional economies	■			■				■		■		■
Reduced long-term system management costs		■		■		■				■		
Increase flood system resiliency and climate change adaptability	■			■					■			■
Ecosystem Restoration Benefits			■	■	■		■				■	
Water Management Benefits				■	■	■				■		
Open Space and Recreational Opportunities				■	■	■				■		

Key:
CVFPP = Central Valley Flood Protection Plan
P&G = *Economics and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*
PR&G = Principles, Requirements and Guidelines

3.2 Benefit Assessment Approach

The benefit categories considered in the 2012 CVFPP encompass a wide range of benefits, requiring detailed data and analyses. However, because the CVFPP is primarily a systemwide reconnaissance study and not a detailed feasibility study, information is limited for conducting detailed analyses to quantify benefits. For the 2012 CVFPP, a mix of quantitative and qualitative assessments was conducted for the various benefits considered, consistent with the available data and details of proposed flood improvement actions and projects.

Table 3-2 identifies the analysis method (quantitative or qualitative) applied to the various benefits considered. Quantitative analyses have been conducted for the following benefits:

- **Improved Public Health and Safety** – Reduction in life risk has been quantified for each of the preliminary approaches and the SSIA, using USACE Hydraulic Engineering Center Flood Damage Analysis Model (HEC-FDA). This analysis is documented in Attachment 8G: Life Risk Analysis.
- **Reduced Economic Flood Damages** – Flood damage reduction benefits were assessed for (1) structure and content values, (2) agricultural crop production, and (3) business income. These benefits were assessed for each of the preliminary approaches and the SSIA, using HEC-FDA. The flood damage reduction analysis is documented in Attachment 8F: Flood Damage Analysis.
- **Benefits to Local and Regional Economies** – Secondary "ripple" effects are associated with avoided flood-related business losses and construction expenditures. These secondary effects include indirect and induced industry output and employment (both short term and long term) resulting from direct effects. Secondary effects were only assessed for the SSIA, as described in Attachment 8H: Regional Economic Analysis.

Benefits quantitatively and qualitatively evaluated are summarized in Section 4 and Section 5, respectively. Figure 3-1 illustrates the CVFPP economic assessment approach.

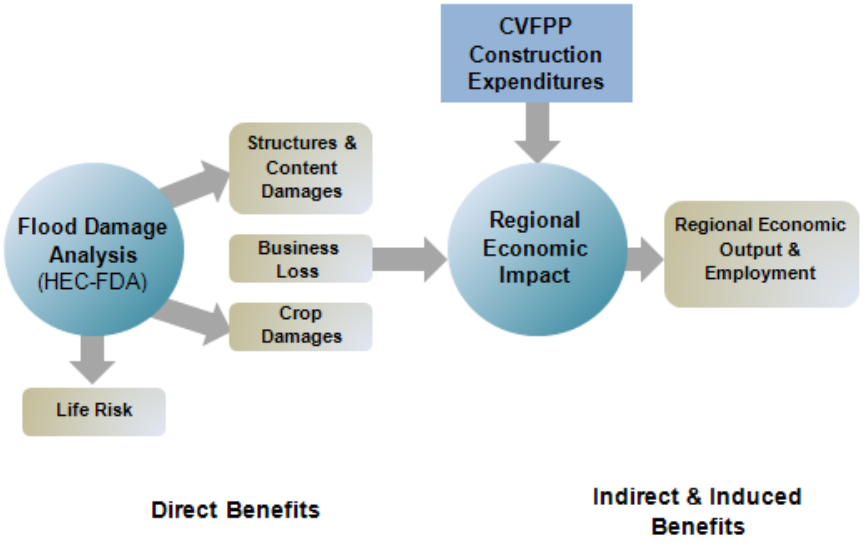

Figure 3-1: CVFPP Economic Assessment Approach

Table 3-2. Analysis Approach Applied to Assess Benefits Considered in 2012 CVFPP

Considered Benefits	Quantitative Analysis		Qualitative Analysis
	Preliminary Approach	SSIA	
Improved Public Health and Safety			
Reduced potential for injuries and loss of life	■	■	
Reduced release of hazardous materials during floods			■
Reduced Economic Flood Damages			
Reduced structures and content damages	■	■	
Reduced agricultural crop losses	■	■	
Reduced livestock losses			■
Reduced damages to public infrastructure			■
Avoided business income losses	■	■	
Benefits to Local and Regional Economies			
Increased benefits to regional economies		■	
Enhanced agricultural sustainability			■
Reduced disruption of public services			■
Reduced Long-Term Flood System Management Costs			
Reduced long-term emergency response and recovery needs			■
Reduced long-term operations and maintenance costs			■
Efficiency through regional approaches to permitting and regulatory needs			■
Increasing Flood System Resiliency and Climate Change Adaptability			■
Ecosystem Restoration Benefits			
Improved riparian habitat quantity, quality, and connectivity			■
Improved fish passage and habitat			■
Improved natural geomorphic processes			■
Water Management Benefits			■
Open Space and Recreation Opportunities			■

Key:
CVFPP = Central Valley Flood Protection Plan
SSIA = State Systemwide Investment Approach

3.3 Benefit Categories Not Considered

Benefit categories not considered for the 2012 CVFPP include hydropower, navigation, and water quality. Although the CVFPP may in small ways contribute to each category, it would likely not be significant, and therefore is not considered here.

4.0 Benefits Quantitatively Assessed for 2012 CVFPP

This section summarizes the flood risk management benefits that were assessed quantitatively: improved public health and safety, reduced potential for economic flood damages, and benefits to local and regional economies.

4.1 Improved Public Health and Safety –Reduced Potential For Injuries and Loss of Life

Currently, about 1 million people and more than $64 billion of assets in the Central Valley are protected from flooding by facilities of the SPFC. The public safety threat related to flooding is high for many communities, particularly those in deep floodplains: 84 percent of the population has less than 100-year protection. The preliminary approaches and the SSIA reduce life risk to different degrees, employing different flood management features and methods.

Table 4-1 summarizes estimated annual life risk values for the Sacramento and San Joaquin river basins, for the No Project condition and 2012 CVFPP approaches. These values are the expected annual statistics computed by HEC-FDA. The differences in life risk values for each approach, compared to No Project, are the benefits of that approach.

Figure 4-1 displays the percent reductions in life risk results for the Sacramento and San Joaquin river basins and all approaches studied, compared to the No Project condition. All of the approaches reduce life risk compared to the No Project condition, with the greatest reduction attributable to the SSIA, followed by the Protect High Risk Communities Approach. This is due to the focus on protection of population centers in both approaches.

Life risk values are *conditional*: they represent consequences for a given area with a specified set of hydrologic and hydraulic conditions for the system, with best representation of performance of system levees and other features, and with stated assumptions regarding public warning and response. Therefore, results are informative indices of life risk, and the values shown herein provide a reliable metric for comparing the life risk reduction attributable to the proposed 2012 CVFPP approaches.

Table 4-1. Summary of Annual Life Risk Values and Benefits for Sacramento and San Joaquin River Basins

CVFPP Approaches	Sacramento River Basin	San Joaquin River Basin	Total
Life Risk Values			
No Project	58.6	4.1	62.7
Achieve SPFC Design Flow Capacity	55.9	4.0	59.9
Protect High Risk Communities	31.5	3.9	35.4
Enhance Flood System Capacity	44.5	2.2	46.7
State Systemwide Investment	28.1	3.9	32.0
Life Risk Benefits[1]			
No Project	N/A	N/A	N/A
Achieve SPFC Design Flow Capacity	2.7	0.1	2.8
Protect High Risk Communities	27.1	0.2	27.3
Enhance Flood System Capacity	14.1	1.9	16.0
State Systemwide Investment	30.5	0.2	30.7

Notes:
1. The reduction in life risk values of each approach compared to No Project.
Key:
SPFC = State Plan of Flood Control

These life risk benefits are planning estimates to be used as indices comparing the relative performances of the proposed 2012 CVFPP approaches in reducing flood life risk, to inform the decision making process. However, these results are not forecasts of *deaths* expected to occur from flood events to be used for emergency planning or other purposes; that would require much more detailed analyses and supporting data than used in this analysis. The life risk analysis conducted for the 2012 CVFPP is documented in Attachment 8G: Life Risk Analysis.

Changes in the release of hazardous materials attributable to the 2012 CVFPP approaches were not quantified.

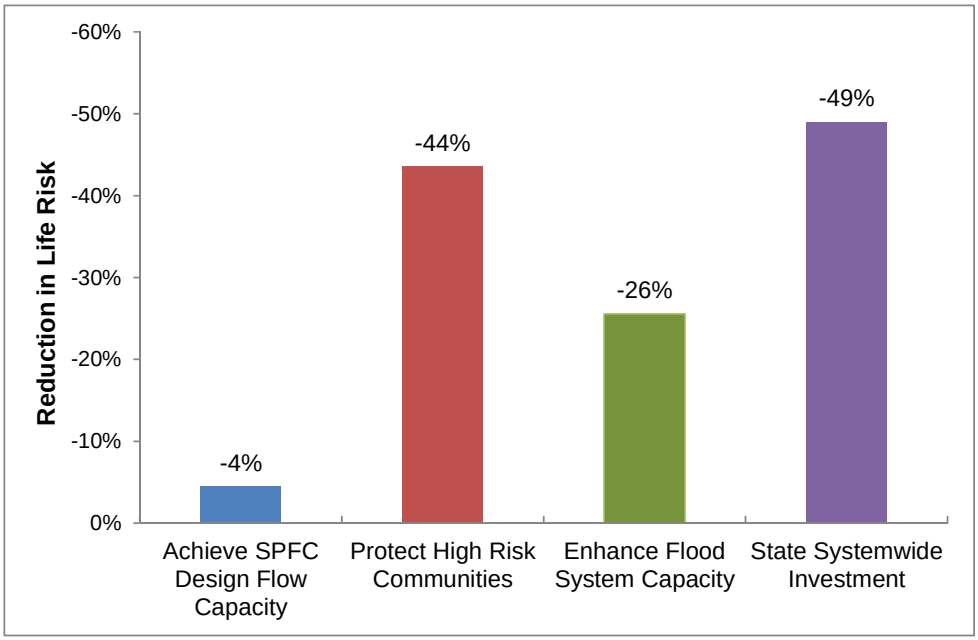

Figure 4-1. CVFPP Approach Life Risk Value Percent Reductions Compared to No Project Condition for Sacramento and San Joaquin River Basins

4.2 Reduced Economic Flood Damages

The preliminary approaches and the SSIA would reduce direct, economic damages from floods to varying degrees due to the proposed flood management improvements. Results of the flood damage analysis are given as expected annual damage (EAD). EAD is not a predictor of damages for a given year, but rather indicates the annualized damages from periodic flooding. For this study, the EAD has three components:

1. Annual structure and contents damage
2. Annual crop damage
3. Annual business losses

Table 5-2 compares total EAD for the Sacramento and San Joaquin river basins, for the No Project condition and for each of the four flood management approaches. The differences in EAD for each approach, compared to No Project, are the benefits of that approach.

Figures 4-2 and 4-3 also show EAD for both basins by approach and by type of flood damage (structures, crops, and business losses). The methods and data used to estimate EAD are described in Attachment 8F: Flood Damage Analysis.

In the Sacramento River Basin, the SSIA provides the largest reduction in economic flood damages, followed by the Protect High Risk Communities Approach. This is likely because of the larger percentage of the damages in the basin that would occur in urban areas, and both of these approaches would provide 200-year protection to urban areas.

In the San Joaquin River Basin, the Achieve SPFC Design Flow Capacity Approach provides the largest reduction in economic flood damages, followed by the Enhance Flood System Capacity Approach. This is because of a larger percentage of the damages in the basin would occur in rural areas.

Table 4-2. Summary of Annual Flood Damage and Benefits for Sacramento and San Joaquin River Basins (2010 dollars, in millions)

CVFPP Approaches	Sacramento River Basin	San Joaquin River Basin	Total
Annual Flood Damage			
No Project	$303	$26	$329
Achieve SPFC Design Flow Capacity	$176	$13	$189
Protect High Risk Communities	$101	$21	$122
Enhance Flood System Capacity	$174	$17	$191
State Systemwide Investment	$91	$21	$112
Annual Flood Damage Benefits[1]			
No Project	N/A	N/A	N/A
Achieve SPFC Design Flow Capacity	$127	$13	$140
Protect High Risk Communities	$202	$5	$207
Enhance Flood System Capacity	$129	$9	$138
State Systemwide Investment	$212	$5	$217

Notes:
1. The reduction in EAD of each Approach compared to No Project

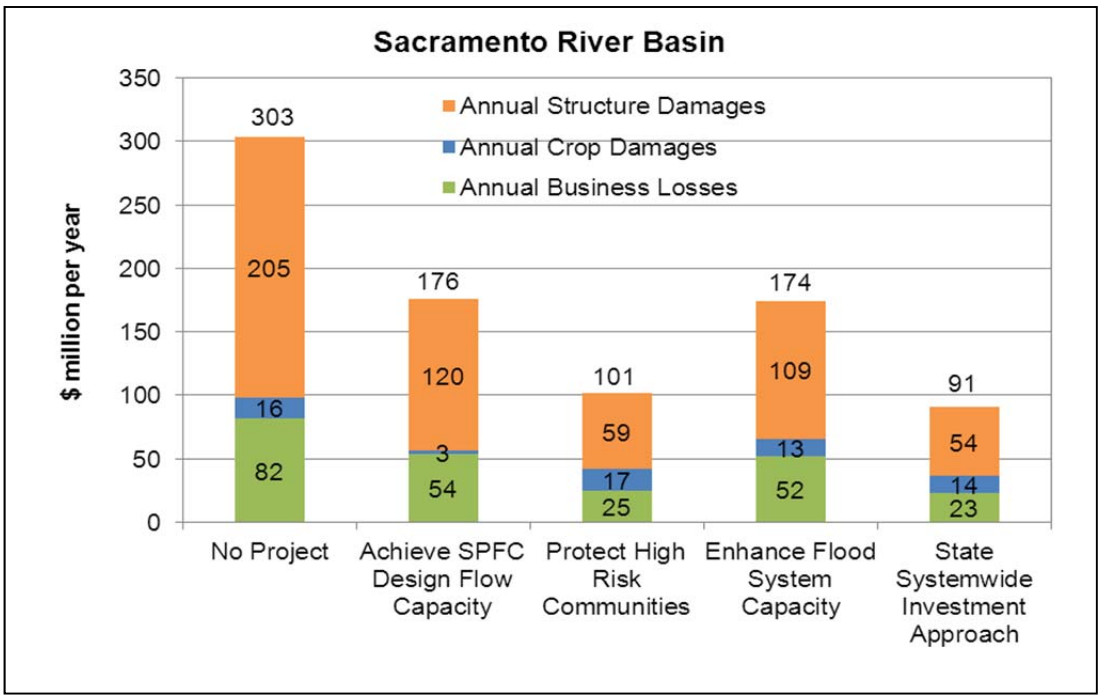

Figure 4-2. Sacramento River Basin Estimated Annual Flood Damages

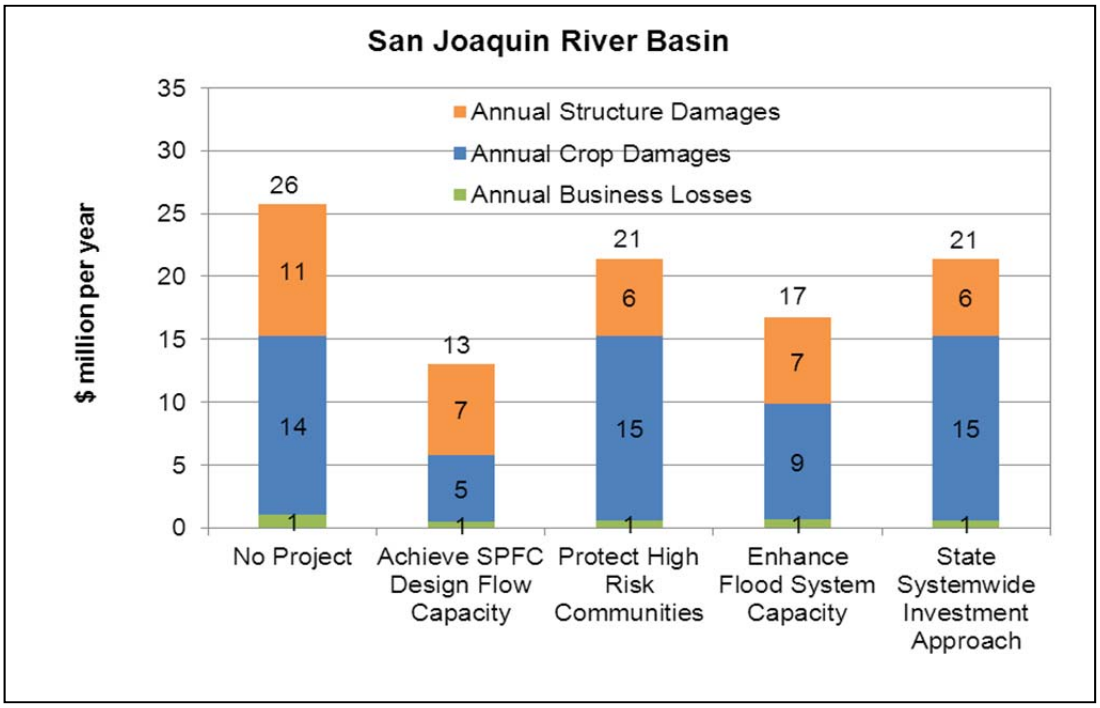

Figure 4-3. San Joaquin River Basin Estimated Annual Flood Damages

Reductions in EAD (and life risk) do not include the effects of FloodSAFE early implementation projects implemented between 2007 and 2012, which have made progress in reducing potential economic damages within the valley. Since 2007, the State has invested approximately $1.6 billion to improve flood emergency response, operations and maintenance, and floodplain risk management, and to participate in flood risk reduction projects and various assessments. One of these programs is DWR's Early Implementation Program (EIP), in which the State invested almost $540 million (in addition to the $204 million invested by local agencies) for significant levee improvements in the Central Valley. These projects are considered part of the SSIA and have already realized significant flood risk reduction and related benefits. It is estimated that these benefits significantly exceed the nearly $800 million cost to implement the projects to date. The benefits displayed in this report are considered additional benefits that could be achieved by implementing the remaining elements of the SSIA.

Because the flood damage reduction benefit assessments for the EIP projects used methods and tools consistent with those used for the CVFPP, the CVFPP did not reestimate benefits for these projects. Thus, the base year for the CVFPP flood damage reduction analysis is 2010 for projects expected to be implemented following the EIP program. This base year implicitly assumes implementation of the EIP projects.

4.3 Benefits to Local and Regional Economies

Implementing approaches formulated for the 2012 CVFPP would directly and indirectly benefit local and regional economies and support continued economic development in the Central Valley. For example, implementation would reduce the potential for lost agricultural, commercial, and industrial production/ income, and secondary "ripple" effects, as a result of a flood. The potential for flood-impacted industries to recover to pre-flood levels would also be improved. In addition, construction projects resulting from implementing the 2012 CVFPP would be expected to boost regional short-term employment and employment incomes, and increase regional economic output. Long-term employment may also be either sustained or improved as flood management improves in the valley. These employment and economic output benefits would also affect revenues of local governments through increased income and sales taxes.

Table 4-3 displays the direct, indirect, and induced employment and economic output effects resulting from:

- Construction expenditures related to the implementation of the SSIA over a 20 year period
- Avoided annual flood-related business losses (direct business losses are also included in the EAD estimates)

However, these secondary economic effects were not estimated for the other approaches. The methods and data used to estimate regional economic effects are described in Attachment 8H: Regional Economic Analysis.

Table 4-3. Estimated Direct, Indirect, and Induced Regional Employment and Output Effects of SSIA

Effects	Sacramento River Basin	San Joaquin River Basin	Total
Employment (Jobs)			
Project Construction[1]	4,400 – 6,000	700 – 900	5,100 – 6,900
Avoided Business Losses[2]	847	5	852
Economic Output ($2010 millions)			
Project Construction[3]	$624 – $800	$96 – $110	$720 – $910
Avoided Business Losses[4]	$100	$0.7	$101

Notes:
1. Average annual employment over a 20-year period.
2. Long-term average annual avoided employment losses.
3. Increase in average annual economic output over a 20-year period.
4. Long-term average annual avoided economic output losses.

Key:
SSIA = State Systemwide Investment Approach

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5.0 Benefits Qualitatively Described for the 2012 CVFPP

This section describes flood risk management benefits assessed qualitatively in the 2012 CVFPP.

5.1 Improved Public Health and Safety

Flood management improvements can reduce the potential for injuries and loss of life and release of hazardous materials during floods. Reduction of life loss was assessed quantitatively, as summarized in Section 4. Reduction of potential for release of hazardous materials is described below.

5.1.1 Reduced Release of Hazardous Materials During Floods

Floods can cause a release of hazardous materials, resulting in increased threats to public health and safety. Hazardous materials may exist in floodways, such as feed lots, fuel tanks, septic systems, landfills, areas of illegal dumping, or other sources. Wastewater treatment facilities within the floodplain are associated with urban areas, small communities, and individual rural-agricultural properties. These threats include the mobilization of hazardous materials and contaminants in the floodplain, mobilization of sediments, and contamination from water treatment and wastewater treatment facilities. Improved flood management under the CVFPP would contribute to reducing public exposure to the release of hazardous materials and will improve water quality.

5.2 Reduced Economic Flood Damages

Flood management improvements can reduce damages to structures and content (residential, commercial, industrial, and government buildings), agricultural crop losses and livestock losses, damages to public infrastructure (transportation, energy, utilities, etc.), and business income losses. Reduction of damage to structures and contents, crops, and business income were assessed quantitatively, as summarized in Section 4. Potential reduction in livestock losses and damage to public infrastructure is discussed below.

5.2.1 Reduced Livestock Losses

Potential agricultural crop losses from flooding were estimated for the 2012 CVFPP. Expected annual crop losses would be reduced over current conditions under the Achieve SPFC Design Flow Capacity and Enhance Flood System Capacity approaches, and the SSIA. Potential livestock losses were not estimated, but reductions proportional to crop losses could be expected.

5.2.2 Reduced Damages to Public Infrastructure

More than 2,800 public facilities (including more than 1,500 highway bridges and about 700 schools), over 1,800 miles of transportation segments (including major highways), and numerous power, water, and gas utilities are at risk of flooding in the Central Valley. The potential for damages to public infrastructure was not explicitly estimated for the 2012 CVFPP, but would be substantially reduced, compared with current conditions.

5.3 Benefits to Local and Regional Economies

Flood management improvements can reduce the potential for loss of production and for industry relocation, effects on employment, impacts on agricultural sustainability, and disruption of public services. Section 4 presents the quantitative assessment of employment and industry output effects of the proposed improvements. Effects related to agricultural sustainability and disruption of public services and are discussed below.

5.3.1 Enhanced Agricultural Sustainability

Central Valley agriculture is a critical sector of the State economy that provides and supports reliable, affordable food and fiber production both domestically and on a global scale. Flood management improvements would improve agricultural sustainability through the following:

- Reducing direct tangible crop damages
- Increasing producers' ability to obtain favorable crop insurance coverage and rates
- Increasing producers' ability to obtain more agricultural loans and with favorable terms

- Preserving the employment associated with related processing industries and services

- Preserving agricultural land uses in the floodplain through the purchase of agricultural conservation easements

5.3.2 Reduced Disruption of Public Services

CVFPP flood management improvements would reduce the potential for disruption to public services critical to maintaining the health, safety, and welfare of the population. These critical functions include emergency services, transportation, health care, education, and public utilities (e.g., water and wastewater, electricity, natural gas, communications). Interruption of these services and functions would greatly affect socioeconomic conditions in the region and the region's economic and industrial diversity. The 2012 CVFPP did not quantitatively assess the loss of functions for public services, but it has estimated the number of critical facilities *exposed* to the flood hazard. This analysis is described in Attachment 8F: Flood Damage Analysis.

5.4 Reduced Long-Term System Management Costs

Flood management improvements can reduce system management costs through reduction of long-term emergency response and recovery needs, operations and maintenance costs, and efficiency gained through implementing regional approaches to permitting and regulatory compliance.

5.4.1 Reduced Long-Term Emergency Response and Recovery Needs

Implementation of the 2012 CVFPP would reduce flooding in urban areas, small communities, and rural-agricultural areas, thereby reducing flood emergency response and recovery activities and associated costs. Costs related to flood emergency responses and recovery activities can be substantial, especially for urban areas. These costs can be categorized as evacuation, debris removal and cleanup, public services, and public utilities. Evacuation activities include coordination of transportation of people from evacuation zones, housing people in emergency shelters, providing food and water, and reoccupation. Debris removal and cleanup activities include sorting, transporting, processing, and disposing of different types of debris from residential, commercial, and industrial buildings. Public services costs are those required to reestablish disrupted public services such as education, health care, and incarceration.

Floods can also cause a release of hazardous materials, resulting in increased threats to public health and safety. Hazardous materials may exist in floodways, such as feed lots, fuel tanks, septic systems, landfills, areas of illegal dumping, or other sources. Wastewater treatment facilities within the floodplain are associated with urban areas, small communities, and individual rural-agricultural properties. These threats include the mobilization of hazardous materials and contaminants in the floodplain, mobilization of sediments, and contamination from water treatment and wastewater treatment facilities. Improved flood management under the 2012 CVFPP would contribute to reducing public exposure to release of hazardous materials, and would improve water quality.

5.4.2 Reduced Long-Term Operations and Maintenance Costs

Expansion of floodway corridors and realignment of levees to reduce the erosive force of floodwaters on the levees can improve their reliability and reduce repair costs. In reaches where levees closely follow sinuous river channels, setback levees provide opportunities for significantly reducing overall levee length, which may reduce overall maintenance costs. Long-term annual costs can also be expected to decrease because of operations and maintenance reforms (such as clarified roles and responsibilities, consistent standards, and revenue generation improvements) and physical modification to reduce geomorphic stressors.

5.4.3 Efficiency Through Regional Approaches to Permitting and Regulatory Needs

The 2012 CVFPP policies and guidance will improve overall operational efficiency through regional approaches to permitting and regulatory needs, changes and/or clarifications in current State policy directives, legislated authority and responsibilities, and partnerships with federal and local partners. More flexibility in the regulatory framework allows the flood management system to be managed in a more integrated fashion that concurrently and efficiently achieves flood management and environmental objectives. Improving riverine habitat extent, diversity, condition, and connectivity can improve project implementation and operation throughout the flood management system.

5.5 Increased Flood System Resiliency and Climate Change Adaptability

The Enhance Flood System Capacity Approach and the SSIA include a variety of physical elements that increase conveyance, such as bypass and floodway corridor expansions. These improvements would reduce peak flood stage and increase the system capacity to manage and attenuate flood peaks, thereby improving its adaptability to handle future changes in climate and hydrological uncertainty.

5.6 Ecosystem Restoration Benefits

Ecosystems perform many complex and interrelated functions that not only provide basic biological support, but also provide valuable goods and services to society. Work is continuing to quantify the contribution to ecosystems improvements in the CVFPP. These benefits will be a featured valuation category in the 2017 CVFPP. Consistent with the definition of benefit as the increase in value of goods and services, ecosystems can provide (DWR, 2008):

- Biological services that benefit plants and animals inhabiting the ecosystem

- Anthropocentric services that directly benefit humans, such as the maintenance of water supply quantity and quality, soil and air quality, floodwater storage, and recreation

Restoration features integrated in flood management improvements can contribute to improved riparian habitat quantity, quality, and connectivity, and enhanced fish passage and habitat.

A fundamental issue with assessing benefits from improving ecosystem functions is whether those benefits should be expressed in monetary or nonmonetary terms. Methods and tools are available for evaluating ecosystem benefits monetarily or nonmonetarily, as described in DWR's *Economic Analysis Guidebook* (DWR, 2008).

5.6.1 Improved Riparian Habitat Quantity, Quality, and Connectivity

Plan elements – such as widened bypasses and floodways – contribute to realizing a flood management system that works with, rather than against, natural processes, while also supporting restoration of ecosystem functions. Improving species populations and habitat in the flood system depends on

improving hydrologic and geomorphic processes. When these processes function well, efforts for species and habitat conservation are easier, less costly, and have higher long-term viability. Floodway corridor expansion can generate opportunities for improving ecosystem function and increasing habitat extent, quality, and connectivity. The expanded floodway creates space for river meandering, sediment erosion and deposition, natural ecosystem disturbance processes, and a healthy diversity of riverine habitat.

The two broad types of habitat to be created are riparian/floodplain forest and habitat for juvenile fish (often called "rearing habitat"), especially for salmon and steelhead. The former habitat would be developed on lands between setback levees and perhaps in lower velocity zones in bypasses. The latter habitat would be developed or improved primarily in areas planted or maintained in grass or other herbaceous vegetation of low stature, mostly in floodwater bypasses, but also inside setback levees.

The Enhance Flood System Capacity Approach and the SSIA make land available for habitat restoration by increasing the physical capacity of the flood management system with setback levees and new or enlarged floodwater bypasses. The Achieve SPFC Design Flow Capacity and Protect High Risk Communities approaches do not call for these actions; therefore, they have insignificant restoration opportunities, partly because habitat restoration opportunities can be realized only on the waterside of levees.

5.6.2 Improved Fish Passage and Habitat

Fish passage barriers, such as dams, weirs, and water diversions for agricultural and municipal uses, have reduced the amount of salmonid habitat in the Sacramento and San Joaquin river basins, and many diversions also cause the direct mortality of fish. The Enhance Flood System Capacity Approach and the SSIA include projects to improve fish passage at flood diversions, flashboard dams, flood management structures, and pumping stations. This includes connecting fishery habitat from the Delta to the Yolo and Sutter bypasses and Butte Creek. These actions will assist in increasing and improving habitat connectivity and promoting the recovery of anadromous fish populations in the Sacramento-San Joaquin River Flood Management System.

5.6.1 Improved Natural Geomorphic Processes

Changes in flood control facility operations, including directing flows more frequently and for longer durations over weirs and into bypasses, levee setbacks, and other similar measures planned under the Enhance Flood System Capacity Approach and the SSIA would enhance riverine processes and improve the overall health of the ecosystem.

5.7 Enhanced Opportunities to Achieve Multiple Objectives

In addition to improved ecosystem functions, certain flood management features can contribute to other benefits, including water supply management, and recreation and tourism.

5.8 Water Management Benefits

The SSIA, as an integrated flood and water management program, would provide opportunities for improved water management in many ways. While estimates of water management benefits will be quantified for the 2017 CVFPP, DWR expects that the average annual water management benefits of the SSIA may approach a few hundred thousand acre-feet compared to No Project. SSIA elements that could contribute to improved water management include reservoir operations and increases in channel groundwater recharge due to expansion and extension of the bypass system.

- **Reservoir operation –** The Forecast-Coordinated Operations (F-CO) program is designed to modify operation of reservoirs in a way that will improve flood management and also provide opportunities for more aggressive refilling of reservoirs during dry years. Such operations could increase water supplies within reservoirs, especially in dry years when the water supply system is most stressed. Water supply benefits from Forecast-Based Operations (F-BO) would vary depending on current reservoir operation manual requirements, watershed hydrology, flexibility in reservoir operation (i.e., adequate release capacity), quality of reservoir inflow forecasts, etc. Therefore, a case-by-case study of flood management reservoirs will be needed to adequately define and quantify the potential benefits of reservoir F-BO.

- **Groundwater recharge –** Groundwater aquifers are naturally recharged through various processes, including percolation of precipitation and infiltration of water from lakes, canals, irrigation and in-channel groundwater recharge. Implementation of the SSIA includes expansion and extension of the bypass system and levee setbacks. These actions would expand flood system lands by an additional 35,000 to 40,000 acres, which would be flooded during high water and contribute to in-channel and floodplain groundwater recharge.

5.9 Open Space and Recreation Opportunities

The SSIA includes floodplain reconnection and floodway expansion, which improve ecosystem functions, fish passage, and the quantity, quality, and diversity of natural habitats. Depending on various ecological conditions and constraints, many of these improvements can contribute to increasing opportunities for recreation and ecotourism, as well as augmenting the aesthetic values. Expansion of habitat areas provides opportunities for fishing, hunting, and wildlife viewing opportunities. Recreation-related spending associated with increased use by visitors to recreation areas becomes an important contributor to local and regional economies.

6.0 Findings

CVFPP implementation will provide multiple benefits to the Central Valley, the State, and the nation. For some of these benefits, a preliminary quantitative estimate has been made using available data and tools. For other benefits, they are only described in this document in qualitative terms. Significant effort will be made following completion of the 2012 CVFPP to further quantify all benefit categories for the 2017 CVFPP.

Table 6-1 summarizes the average annual benefits that have been quantified for the 2012 CVFPP, by approach, focusing upon the primary CVFPP goal to improve flood risk management.

Table 6-1. Summary of Quantified Annual Benefits

CVFPP Approaches	Reductions in Life Risk Values[1]	Reductions in Flood Damage[1] (2010 dollars, in millions)
Achieve SPFC Design Flow Capacity	-3%	$140
Protect High Risk Communities	-27%	$207
Enhance Flood System Capacity	-16%	$138
State Systemwide Investment	-31%	$217`

Note:
[1] Compared to No Project

Implementations of SSIA would result in employment and increased economic output benefits to the region. These benefits would include short-term benefits associated with the construction expenditure, and long-term avoided business loss benefits resulting from the improved flood protection.

Benefits that were qualitatively described include:

- Improved public health and safety:
  - Reduced potential for release of hazardous materials during floods
- Reduced potential for flood damages:
  - Reduced livestock losses
  - Reduced damage to public infrastructure

- Benefits to local and regional economies:
  - Reduced potential for public service disruption
  - Enhanced agricultural sustainability
- Reduced long-term system management costs:
  - Reduced long-term emergency response and recovery needs
  - Reduced long-term operations and maintenance costs
  - Improved efficiency through regional approaches to permitting and regulatory needs
- Increasing Flood System Resiliency and Climate Change Adaptability
- Improved ecosystem functions:
  - Improved riparian habitat quantity, quality, and connectivity
  - Improved fish passage and habitat
  - Improved natural geomorphic processes
- Water management benefits
- Open space and recreation opportunities

Whether the benefits were evaluated quantitatively or described qualitatively, they are considered to be at an "appraisal," or reconnaissance, level of detail, appropriate for planning broad combinations of policies, programs, and physical improvements.

Based on this appraisal level of detail, the SSAI contributes the most to the 2012 CVFPP primary goal, to improve flood risk management, in terms of estimated reductions in life risk and EAD.

Basin-wide feasibility studies will be conducted before the implementation of specific measures. These feasibility studies will refine and expand on the benefit evaluations conducted thus far for the 2012 CVFPP, as follows:

- Evaluating additional flood risk management benefits, such as infrastructure physical damage and loss of functions to that infrastructure, as well as other assets.
- Evaluating potential multiple benefits, such as ecosystem restoration, water supply management, and recreation.

7.0 References

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8.0 Acronyms and Abbreviations

Board	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
Delta	Sacramento-San Joaquin Delta
DWR	California Department of Water Resources
EAD	Expected annual damages
EIP	FloodSAFE Early Implementation Projects
EQ	environmental quality
F-BO	Forecast-Based Operations
F-CO	Forecast-Coordinated Operations
FloodSAFE	California FloodSAFE
GIS	geographic information system
HEC-FDA	U.S. Army Corps of Engineers Hydrologic Engineering Center Flood Damage Analysis Model
NED	national economic development
OSE	other social effect
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
PR&G	Principles, Requirements and Guidelines
RED	regional economic development
SPFC	State Plan of Flood Control
SSIA	State Systemwide Investment Approach
State	State of California
USACE	U.S. Army Corps of Engineers

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THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES